REMARKS

Claims 1-15 are currently pending in this application. In an Office Action mailed on January 9, 2006, (hereinafter "Office Action"), Claims 1 and 10 were objected to under 35 U.S.C. § 112 as being unclear. Claims 14 and 15 were objected to under 37 CFR 1.75(c) as being improper dependent form for failing to further limit the subject matter of the previous claim.

The Office Action also rejected Claims 1-15 under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,788,838 B2 to Ho et al. (hereinafter "Ho et. al") in view of U.S. Patent No. 6,522,462 to Chu (hereinafter "Chu").

Claims 1, 10, 14, and 15 have been amended to more particularly point out and distinctly claim the subject matter of the present disclosure. In addition, new Claims 16-18, which are fully supported by the present disclosure, have been added.

For at least the reasons set forth below, applicants respectfully request reconsideration and allowance of this application.

Claim objections under 35 U.S.C. § 112

Claims 1 and 10 are objected to because the language "(a) remaining input port(s)" is allegedly unclear. The Office Action sets forth the position that the absence of parenthesis renders the claim indefinite.

In response to the objection, applicants have amended Claims 1 and 10 to recite "one or more remaining input ports." In addition, Claims 1 and 10 have been amended to correct a grammatical error. Applicants respectfully submit that the amendments place the claims in condition for allowance.

Claim objections under 37 CFR 1.75(c)

Claims 14 and 15 are objected to under 37 CFR 1.75(c) as being improper dependent form for failing to further limit the subject matter of the previous claim. Claims 14 and 15 have

been amended to place the claims in proper dependent form. More specifically, Claim 14 has been amended to recite the all-optical flip-flop as disclosed in claim 1, ***wherein the multi-mode interference portion constitutes at least a portion of an oscillator of the semiconductor laser.*** In addition, Claim 15 has been amended to recite the all-optical flip-flop as disclosed in claim 1, ***wherein the input ports and the output ports reflect a part of light generated by the oscillation within the multi-mode interference portion in order to maintain lasing oscillation of the semiconductor laser.***

Applicant respectfully submits that Claims 14 and 15 further limit the subject matter of Claim 1, and are in condition for allowance.

Claim Rejections - 35 U.S.C. § 103

The Office Action rejected Claims 1-15 under 35 U.S.C. § 103(a) as being unpatentable over Ho et al. in view of Chu. To establish a *prima facie* case for obviousness under 35 U.S.C. § 103, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine the reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. MPEP 2142 (August 2005).

First, the basic operational principle of the all-optical flip-flop of the present disclosure will be described. The all-optical flip-flop is basically configured from a laser 1, which includes a waveguide 30 having a multimode interference (MMI) portion 31. Figure 2 shows the basic structure and two lasing modes of the all-optical flip-flop. As shown in Fig. 2, the MMI portion or coupler 31 includes an active (gain) medium and input/output ports 32 and 33 with saturable absorption regions or absorbers 34 for two lasing modes. The input port 32 has a set port 321 and a reset port 322. The output port 33 includes a non-inverting output port 331 and an inverting output port 332. In at least one embodiment of the all-optical flip-flop, mirrors are

located at the edge of the input/output ports to form a cavity for a semiconductor laser. The MMI coupler is capable of transmitting multiple modes of light within (for instance, Mode 1 and Mode 2). The MMI coupler selectively outputs light at the output port by oscillating based on a set pulse and a reset pulse inputted from the input port.

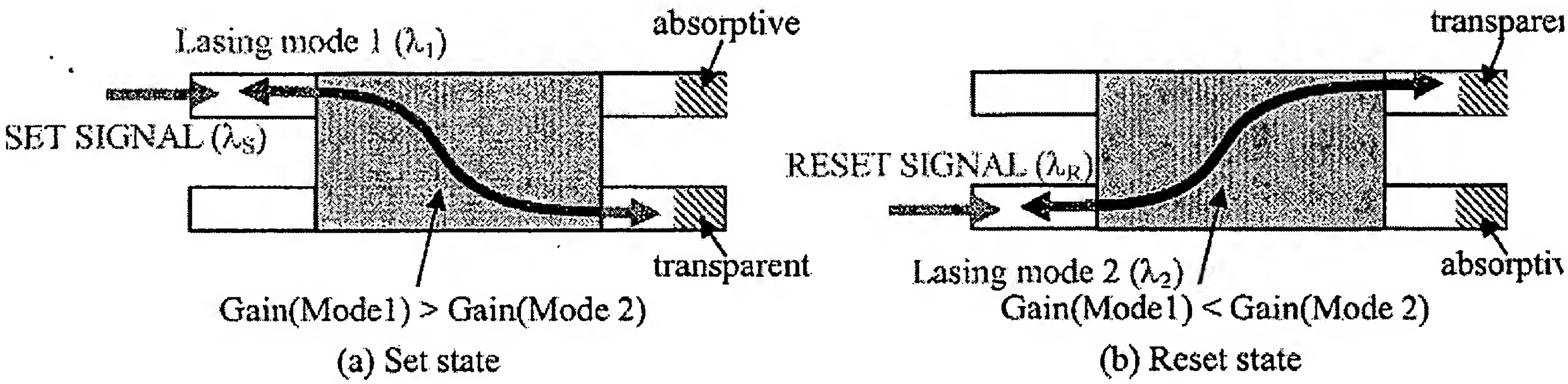

Figure A

The operational principle of the all-optical flip-flop is shown in Figure A above. When SET SIGNAL (λ_S) is injected into the set port, as shown in Fig. A(a), the optical gain for Mode 1 becomes larger than that for Mode 2 through cross gain saturation (Gain(Mode 1) > Gain(Mode 2)). The saturable absorber for Mode 1 becomes transparent by SET SIGNAL (λ_S) and Mode 1 starts lasing. At the same time, the laser radiation of Mode 2 is terminated, and the saturable absorber for Mode 2 becomes absorptive. This set state can be maintained after eliminating SET SIGNAL(λ_S) through cross gain saturation and the absorptive saturable absorber for Mode 2.

As shown in Figure A(b), RESET SIGNAL (λ_R) can switch the flip-flop to the reset state. When RESET SIGNAL (λ_R) is injected as shown in Fig. A(b), the optical gain for Mode 2 becomes larger than that for Mode 1 through cross gain saturation (Gain(Mode1) < Gain(Mode 2)). In addition, the saturable absorber for Mode 2 becomes transparent by RESET

SIGNAL (λ_R), and Mode 2 starts lasing. At the same time, the laser radiation of Mode 1 is terminated, and the saturable absorber for Mode 1 becomes absorptive. This reset state can be maintained after eliminating RESET SIGNAL(λ_R) through cross gain saturation and the absorptive saturable absorber for Mode 1. In this way, the operation principle of the all-optical flip-flop is to select the lasing mode from Mode 1 and Mode 2 by SET SIGNAL(λ_S) and RESET SIGNAL(λ_R), and no coupling coefficient change of the MMI coupler occurs.

Applicants respectfully submit that Ho does not teach or suggest all the limitations of Claim 1. Claim 1 discloses an "all-optical flip flop comprising a semiconductor laser, the semiconductor laser being equipped with a waveguide" having "a multi-mode interference portion" and "a plurality of input ports and output ports ... connected to the multi-mode interference portion, with configuration being such that a set pulse from one or more input ports and a reset pulse from one or more remaining input ports is inputted to the multi-mode interference portion, wherein the multi-mode interference portion transmits multi-mode light within, with light outputted due to oscillation based on the set pulse and the reset pulse inputted from the input ports being selectively outputted from the output ports."

The Office Action sets forth the position that Ho teaches photon transistors, dubbed phosistors, that function similarly as conventional transistors. It further asserts that Figure 7 of Ho shows a general configuration of a phosistor, Figure 7B shows the configuration having the modification of a multi-mode interference configuration, and Figure 10 shows the operation of an optical flip-flop with the multi-mode interference configuration. Furthermore, it is sated that the phosistor comprises a waveguide (Figure 10, element 1002, identified as Waveguide A), a plurality of input ports (1006, 1010, 1014, 1016), an output port (1012 or 1014), and the input and output ports being connected to the multi-mode interference portion, with configuration being such that a set pulse from one or more input ports (1006) and a reset pulse from a

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remaining input port (1016) (referring to column 65, lines 34-45) is inputted to the multi-mode interference portion.

Ho includes an MMI configuration device M600 which includes an MMI Waveguide M6024. Referring to Figure 7B of Ho, the MMI Waveguide M6024 includes a first light pathway along the line A and A' and a second light pathway along the line B and B', with an active medium M608 along the first pathway. Both pathways include an input port and an output port, wherein the output port of the second pathway also serves as an input port. The input port of the first pathway is configured to receive continuous wave (CW) light 618 having wavelength λ_2. Under certain conditions, when the active medium on the pathway reaches transparency and first and second pathways are optically transparent, most of the CW light at λ_2 propagating along the first pathway will be transferred to the second pathway after a coupling length l_c. The CW light at λ_2 then exits from the second pathway at the second output port as light at λ_2. (See Column 40, lines 12-54 and Column 46, lines 23-48).

Based on the above, the MMI configuration device M600 of Ho controls the coupling coefficient between two light pathways. When the active medium is transparent, the second light pathway is coupled to the first light pathway. When the active medium is absorptive, there is no coupling between the pathways. Both pathways form a directional coupler, and a part of the directional coupler of the second pathway is composed of the active medium. Thus, for illustrative purposes only, when a SET SIGNAL λ_H ($\leq\lambda_L$) is injected into the input port of the second pathway, the active medium is changed to transparent. The coupling coefficient of the directional coupler is thereafter changed. Thus, if an ENABLE SIGNAL λ_L is injected into the input port of the first pathway, it is transferred from the first pathway to the second pathway.

On the other hand, when a RESET SIGNAL λ_{LL} ($>\lambda_L$) is injected into the output port of the second pathway, the active medium becomes absorptive and there is no coupling between the first and second pathways. In this case, ENABLE SIGNAL λ_L, which is injected into the input

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port of the first pathway, is not transferred to the second pathway and exits from the output port of the first pathway. Thus, the MMI configuration device of Ho changes the optical path of the signal by modifying the coupling coefficient of the directional coupler through the active medium.

Applicants respectfully submit that the operational principle of Ho differs significantly from the all-optical flip-flop of the present disclosure. Ho requires a coupling coefficient change of the MMI coupler. Moreover, the set and reset operations of Ho require that the SET SIGNALλ_H make the active medium transparent and the RESET SIGNALλ_{LL} make the medium absorptive. Therefore, Ho requires the wavelength condition $\lambda_{LL}>\lambda_L\geq\lambda_H$ for flip-flop operation (See col. 66, lines 14-18). The all-optical flip-flop, on the other hand, does not have a wavelength limitation like Ho because its operational principle is to select the lasing mode rather than changing the optical path.

Moreover, only one mode lases at a time in the active MMI portion of the all-optical flip-flop. All-optical flip-flop operation is achievable because an external set pulse or reset pulse that is injected to the set port or reset port, respectively, selects the mode to lase. The all-optical flip-flop ***selects*** the lasing mode; it does not change the optical path of the signal, as does the MMI configuration device of Ho. Moreover, the all-optical flip-flop requires no coupling coefficient change of the MMI portion, as does Ho. Rather, coupling coefficient change of the MMI portion would disturb flip-flop operation.

In addition, the active medium of Ho is not semiconductor laser. The active medium in Ho merely switches its state between transparent and opaque in response to an input of light in order to select a pathway of the light. The active medium does not oscillate and does not constitute a flip-flop using a semiconductor laser. As stated in column 4, lines 1-10 of Ho, "[o]ther variations of all-optical switching devices exist such as one device (not shown) that uses **a cavity** to enhance the intensity in a medium or to achieve **optical bi-stability**. This device also

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suffers from one or more of the problems and/or drawbacks listed above with regard to the Mach-Zehnder device. These problems make the current all-optical switching devices impractical for applications to form large-scale or dense optical logic circuits." Thus, Ho insists that all-optical switching devices (including optical flip-flops) with a cavity are impractical. On the other hand, the MMI coupler 31 has a cavity because the semiconductor laser requires a cavity to achieve optical bistability. The MMI coupler 31 functions as semiconductor laser as well as an optical flip-flop (See Fig. 4 (b)).

Thus, based on the foregoing, applicants submit that Ho does not teach or suggest all the limitations of Claim 1.

The Office Action recognizes that Ho discusses the phosistor being used only as an optical diode, and Ho does not expressly teach that the phosistor is a semiconductor laser equipped with the limitations of Claims 1 and 10. Moreover, the Office Action recognizes that Ho does not explicitly teach using a circulator, even though a circulator is a species of a mode-selective coupler. However, the Office Action asserts that Chu teaches an all-optical logic device that integrates a semiconductor laser into a single chip with the device by coupling a circulator (99, see Figure 9) to the multi-mode interference portion.

As described above, the active medium of Ho is not semiconductor laser. The active medium in Ho merely switches its state between transparent and opaque in response to an input of light in order to select a pathway of the light. The active medium does not oscillate and does not constitute a flip-flop using a semiconductor laser. Applicant respectfully submits that Chu does not supply what is missing from Ho.

Chu discloses a counter-propagate optical logical device using an interferometer with MMI devices. Chu mentions that the logic input signals can be introduced and propagate in the logic circuit in the opposite direction as the continuous wave input (CW). However, Chu recognizes that this structure could disturb the input CW. Chu states that if the CW is an outside

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laser source, there may be no problem, as an individual laser source might have an isolated device to block any incoming optical power and prevent potential damage to the laser source. The problem may be more serious for integrated optics that have the CW laser source built into a single chip. To overcome this problem, Chu states that an isolator or circulator 99 can be included between the CW input source and the MMI splitter 22. In this manner, Chu states that any optical signal of wavelength (λ_1) propagating in the reverse direction from MMI splitter 22 is removed by circulator 99. (See Col. 8, line 57 to Col. 9, line 8).

In Chu, the MMI portion and the SOA (semiconductor optical amplifier) are disposed separately within the circuit. Referring to Figure 9, the optical logic gates are constructed from Mach-Zehnder Interferometer (MZI) optical circuits. The MMI splitter 22 splits the continuous-wave input into two equal-power signals for the upper and lower branches of the interferometer. Each branch has an SOA. The upper signal to SOA 64 has a phase shift of $\Pi/2$ relative to the 0 phase shift for the lower signal to SOA 66. (See Col. 9, lines 13-23).

Chu does not disclose an optical flip-flop that includes an MMI portion used in a waveguide of semiconductor laser where the mode of oscillation in the MMI portion is switched in response to input light and output light. Rather, the MMI coupler of Chu includes only a passive medium for merely selecting the path for the light. Similarly, the active medium in Ho merely switches its state between transparent and opaque in response to an input of light in order to select a pathway of the light. The active medium does not oscillate and does not constitute a flip-flop using a semiconductor laser. Thus, Ho, in view of Chu, does not teach suggest each and every aspect of Claim 1 of the present disclosure.

Claim 10 recites all the limitations of Claim 1, and additionally recites that light is "outputted due to oscillation based on the set pulse and the reset pulse inputted from the input ports being selectively outputted from the output ports ***using multimode interference***."

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Therefore, for the same reasons set forth above with respect to Claim 1, applicants respectfully submit that Ho, in view of Chu, does not teach or suggest every limitation of Claim 10.

Claim 2-9 depend from Claim 1; therefore, Claim 2-9 include all the limitations of Claim 1. Claim 11-18 depend from Claim 10; therefore, Claim 11-18 include all the limitations of Claim 10. Thus, for the same reasons set forth above with respect to Claim 1 and 10, applicant respectfully submits that dependent Claims 2-9 and 11-18 are not taught or suggested by Ho in view of Chu and are therefore in condition for allowance.

Respectfully submitted,

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